Concept of C4I data fusion command center for urban operations

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Abstract

Within the last decade, military research on urban operations (UO) have become a critical challenge. Beirut, Mogadishu, and Grozny, are few examples of urban operations that highlight our actual doctrinal and/or material gaps. From a command and control perspective, the proposal for an urban data fusion command center (UDFCC) is already qualified as a key for urban operations success. The UDFCC main objective is to provide a robust understanding of an urban battlefield. This paper presents a summary of urban operations lessons learned in order to define the UDFCC sub-objectives and components. They are associated with the phases of the intelligence cycle: direction, collection, processing and dissemination. They are categorized into four themes: mission planning and rehearsal; synthetic urban battlefield up to date reproduction and formalization; urban battlefield data exploitation; and synthetic urban battlefield visualization.

1. Introduction

Urban areas are the centers of finance, politics, transportation, communication, industry, society, and culture. Therefore, they have often been the scenes of important military operations, both combat and noncombat [U.S. Army, 2000]. Figure 1 presents the cities contested during the twentieth century conflicts.

About halt of the world's (50%) population lives in cities today and 70% will live in urban areas in 25 years [U.S. MCWL, 1998]. World population is expected to grow from 6 billion to 9 billion over the next 20 years. The average age of population might fall dramatically. This could create massive pressure on resources, from basics such as food and water to those provided by wealth like employment, education and health care. There will be a growing competition for agricultural land and an increased urbanization [Dick, 2001].

For military operations, urban battlespace can be depicted as a complex terrain where we can expect to be providing humanitarian assistance in one part, conducting peacekeeping in another part, and fighting highly lethal mid-intensity battle in yet a third part of the city [Krulak, 1997].

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CITY	YEAR	CITY	YEAR
RIGA	1917	*SEOUL	1950
MADRID	1936	BUDAPEST	1956
WARSAW	1939	*BEIRUT	1958
ROTTERDAM	1940	*SANTO DOMINGO	1965
MOSCOW	1942	*SAIGON	1968
STALINGRAD	1942	*KONTUM	1968
LENINGRAD	1942	*HUE	1968
WARSAW	1943	BELFAST	1972
*PALERMO	1944	MONTEVIDEO	1972
*BREST	1944	QUANGTRI CITY	1972
*AACHEN	1944	SUEZ CITY	1973
ARNHEM	1945	XUAN LOC	1975
ORTONA	1944	SAIGON	1975
*CHERBOURG	1944	BEIRUT	1975
BRESLAU	1945	MANAGUA	1978
*WEISSENFELS	1945	ZAHLE	1981
BERLIN	1945	TYRE	1982
*MANILA	1945	*BEIRUT	1983
JERUSALEM	1967	NICOSIA	1958
*SAN MANUEL	1945	SIDON	1982
ALGIERS	1954	*COLON	1989
CARACAS	1958	*MOGADISHU	1993
*PANAMA CITY	1989	*KUWAIT CITY	1991
*GRENADA	1983	*MONROVIA	1994
*PORT AU PRINCE	1996	*SARAJEVO	1996
		*BRCKO	1997
*Direct US troop involvement.			

Figure 1: Cities contested during the twentieth century conflicts [U.S. Army, 2000]

Urban terrain possesses all of the characteristics of the natural landscape, coupled with manmade construction. Countless rooms, hallways, stairwells, streets, alleys, subterranean corridors, rooftops, and internal space make the task of controlling the urban area near impossible. Considerations unique to the urban environment include the lack of ability to blend in with the terrain and population, decreased operating areas due to the vertical structures and subterranean systems, and degraded communications due to "urban canyons" [Sumner, 2001]. Consequently, urban areas deprive well-equipped armies (high-tech forces) of many of the technical advantages that were developed during the Cold War. Urban areas constrain maneuver, strain C3I systems, and raise substantial political problems by putting non-combatants and non-military targets in the way of military forces [Peters, 1997a][Hahn and Jezior, 1999]. As a result, even a 20:1 exchange rate might not be a big enough advantage for U.S. Forces [Press 1999]. This ratio is quantified to a range between 9:1 and 27:1 i.e. 27 attackers per defender by [U.S. Army, 2000]. The previous ratios can encourage adversary - regular troops, criminal gangs, vigilantes and paramilitary factions - to bring conflicts within urbanized areas, then removing their disadvantage against trained regular forces.

Snipers that reveal being very lethal, hidden booby traps that can be placed in almost everything, friendly shoots, and the limited effectiveness of heavy weaponry, are representative threats of the actual urban combats at the tactical level. This atypical form of engagement added to the previous urban characteristics can partially explain the strong asymmetry mentioned earlier about casualties. Consequently, trained troops become particularly vulnerable to psychological disorder in urban operation contexts. The lessons learned from the Russian Army in Grozny relate a survey conducted over 1300 troops made immediately after the fighting. Psychological disorder occurred for about 72% them [U.S. Army, 2000].

[Betts 2002] highlights the intelligence -especially human intelligence (HUMINT)- as being the key for counterterrorism, which is by essence invisible and based on the capacity to conspire. Urban operations are somewhat similar by the fact that inside buildings, battles are invisible. Every room can be considered as a new battle. Thus, the complexity of the terrain easily overwhelms planning and operation conducts. As a result, it became accepted that the main operational effort, traditionally placed on the engagement, must now be placed on the understanding of the situation. The understanding, first event of a sequence named USECT, which stands for understanding, shaping, engagement, consolidation and transition, encompasses the gathering, the processing, the communicating and the displaying of information regarding all aspects of an urban operation [Hurley, 2001]. For example, the understanding process could enhance diplomatic, economic and information efforts, which may or may not be combined with the military instrument of power. Moreover, understanding could reveal second or third order effects to every military action in urban settings [Sward, 2001]. Understanding is then considered as the key factor to create and maintain temporal advantages within our forces.

The objective of this paper is to propose a concept of C4I data-fusion command center (UDFCC) for urban operations. The primary objective of this center concerns situation understanding. UDFCC is designed according to the following three facets: interface, data storage, and processing [Pigeon, 2002]. The interface is considered as the link between the physical-system and its users and is characterized by goal definitions, required accuracies and determination of sequence of events. The proposed data structure is based on the world physical representation of space and time. A possible-worlds dimension enhances the system to support *a priori* knowledge of the problem, simulations, as well as the recording of past events. The processing unit of the proposed system design handled data fusion and resources management and enhanced a learning component definition, which introduces "intelligence" within the system.

Section 2 presents considerations related to the design of systems. The lessons learned from urban operations follow next. The cases of Grozny and Mogadishu introduce a selection of general lessons and challenge related to urban operations. Section 3 presents the UDFCC sub-objectives and components associated with the phases of the intelligence cycle: direction, collection, processing and dissemination. They are categorized into four themes: mission planning and rehearsal; synthetic urban battlefield up to date reproduction and formalization; urban battlefield data exploitation; and synthetic urban battlefield visualization.

2. Design considerations and urban operations lessons learned

This section presents the link between the physical-system UDFCC and its users with regard to the identification of objectives, of accuracies, and of the sequence of events. Strategically, the system objective is:

To provide a robust understanding of an urban battlefield.

To achieve this objective, data from multiple sources are involved e.g. image intelligence (IMINT), signal intelligence (SIGINT) and human intelligence (HUMINT). Within this context, data-fusion process is used to reduce overloads, and integrates uncompleted and uncertain data. Data-fusion is

defined with respect to the data-fusion definition of [Li *et al* 1993] generalized to "the combination of a group of inputs with the objective of producing a single output of greater quality and reliability".

Within this context, the group of inputs corresponds to the all-source intelligence. The output is a synthetic urban battlefield, which integrates all inputs from the merging, the fusion and the learning process. The potential output users range from the commanding officer to every parts of the system, both physical and human sensors. Consequently, enhanced understanding of the battlefield might allow efficient resources management, which new outputs would feedback the system with new inputs of greater quality. Augmented by a processing component that performs data analysis for threat assessment, the data flow between data-fusion and resource management can be a key to ensure sensors integrity through the avoidance of threats.

The search for a robust system design for the understanding of urban battlefields must start from past operations learned lessons. The latter and the urban problem presented in the introduction drives the UDFCC sub-objectives assessment. The next sub-sections present urban operations learned lessons, the UDDFCC sub-objectives and accuracies, with respect to the DITE sequence of events. This sequence can be defined as:

- **Detect**: discover or perceive the existence of an object.
- **Identify**: quantify the object attributes in order to meet conditions for perfect exhaustiveness and/or precision.
- **Track**: monitor object with regard to the time dimension.
- **Estimate future state**: predict an object (including situation) status over time, including generation of possible world(s) associated to possible COAs. For example, this can stand for a damage estimate for a possible engagement.

The next paragraphs are based on the lessons related by [Sumner, 2001][Thomas, 1999] and [U.S. Army, 2000]. The focus is placed on topics that can be assessed by a better understanding of the urban battlefield. However, a small number of other lessons are also enumerated in order to give a minimum view about urban operations in general.

A foremost lesson concerns the use of intelligence. It is crucial to consider each phase of the intelligence cycle [Canada National Defence, 1998] as a challenge. Direction, collection, processing and dissemination have to receive all the possible attention. For example, in spite of a valuable information holds, a wrong dissemination (e.g. representation and display) might discard all the previous efforts made by direction, collection and processing. A common error, which is not exclusive to urban operations, is to underestimate the enemy effectiveness, military discipline and fighting spirit. Chechens and Somalis having been considered as primitives are examples of this underestimation within urban operations. Table 1 presents a selection of lessons learned from military operations in Grozny and in Mogadishu.

Selection of lessons learned – Grozny and Mogadishu
Lack of official maps forced troops to rely on tourist maps.
Boundaries between units were still tactical-weak points, but it was not just horizontal boundaries that were to worry about. In some cases, the Chechens held the third floor and above, while the Russians held the first two floors and sometimes the roof.
Mine and booby-trap awareness was hard to maintain.
Tactical communications proved very difficult in Grozny.
Night fighting was the single most difficult operations in Chechnya.
Disinformation, deception, and other form of information warfare were used extensively by both sides during the battle for Grozny.
Chechens received extensive outside assistance despite efforts to stop it.
Hit and run ambush attacks by small groups were the most favored and effective of the Chechen tactics.
Both sides employed off the shelf equipment for communications, etc.
Occurrence of poorly defined lines of command and control.
Russians suffered a lack of training for basic maneuver and combat skills.
The logistical unit soldiers were hopelessly inept at basic military skills, such as perimeter defense, establishing security overwatch, and so forth.
UAVs were used extensively and were very effective.
Composite units were generally unsatisfactory.
Standard Russian military units configurations were inappropriate.
Trained snipers were essential, but in short supply.
Tanks and APCs cannot operate in cities without extensive dismounted infantry support.
Non-lethal technologies were seldom used.
Both physical and mental health of the Russian units began to decline almost immediately upon initiation of high intensity combat (e.g. viral hepatitis, chronic diarrhea, upper respiratory infections; exaggerated startle response, neuro-emotional behaviors; and acute emotional reactions).
Difficulties in providing logistical support to the front line.
Reduced effectiveness for transportation and fire support assets.
Difficulty to unite police and military in a single, cohesive force

Table 1: Selection of lessons learned from Grozny, Beirut and Mogadishu

The particular examples in table 1 and the historic operations of figure 1 lead to some generalizations. Table 2 presents these general conclusions related to some of the lessons learned within urban operations.

General conclusions
The geometry and perspectives of urban combat are very different from combat in the open area. Urban combat is much more vertically oriented.
The nature of cities tends to channel combat operations along narrow lanes of activities.
Difficult target acquisition.
The enemy is at close range, then short engagement ranges.
RPGs can be used against helicopters.
Helicopters are not well suited for urban combat.
Heavy machine guns still offer good defense against close air attack, especially helicopters.
Air defense guns are valuable for suppressing ground targets.
Snipers are always present.
Indigenous forces can improvise crude chemical weapons using hazardous materials from the urban area.
Obscurants are especially useful when fighting in cities.
The opposing force is frequently indistinguishable from the civilian population.
Population control is critical.
Fratricide is a serious and continuing problem.
Distinct tactical advantages accrues to the side with less concern for the safety of the civilian population.
Stress is extremely high.
The primacy of infantry (particularly through and for HUMINT).

Table 2: General conclusions from lessons learned

Table 1 and table 2 elements can be categorized within the terrain attributes and within the dynamic of object/components/agents interacting on this terrain. For the object/components/agents, a sub-category might group the elements related to the attackers forces configuration and attributes. The category of *terrain attributes* might include the geometry of terrain, the nature of cities, the close and short engagement ranges, etc. Difficulties related to target acquisition, to the omnipresence of snipers, and to the occurrence of fratricide, are instances of the influence of urban terrain on the *dynamic of the object/components/agents*. Similarly, the effectiveness of UAVs, the qualification about snipers and their short supplies, the difficulty to unify military and police units, the level of stress and the primacy of infantry are examples of lessons related to the attackers forces configuration and attributes.

From the previous tables, possible challenges can be identified. Table 3 presents few identified challenges issued from urban operations lessons learned.

Challenges
Key munitions and systems: defeating the enemy while reducing collateral damage and friendly casualties requires a new set of munitions and systems.
Rigorous communication security is essential.
Rules of engagement clear definition can result in a battlefield that will no longer be invisible to outside observers.
Both reducing collateral damage and friendly casualties, which were traditionally exclusive, have to be achieved.
Strategic bombing can be used in urban operations to shape the battlefield.
Combatants have to be sorted out of non-combatants.
Forces have to be culturally oriented.
Situation training would have improved Russian military effectiveness.

Table 3: Challenges for urban operations

Exhaustiveness would have required a challenge for each particular or general lesson mentioned previously. UDFCC objectives would then correspond to the general categories that would include a potential exhaustive list of challenges for urban operations.

3. UDFCC Objectives/Components

From the main objective *to provide a robust understanding of an urban battlefield* and from the urban operations lessons learned, the next objectives are proposed for UDFCC design. These objectives are described through the system's components, which propose their achievement. The objectives/components are described with respect to the DITE sequence, to the intelligence cycle [Canada National Defence 1998], and to the five-dimensions data structure (x,y,z,t,w) proposed by [Pigeon, 2002a].

The UDFCC objectives/components are categorized within:
- Mission planning and rehearsal (Direction)
- Synthetic urban battlefield up to date reproduction and formalization (Collection)
- Urban battlefield data exploitation (Processing)
- Synthetic urban battlefield visualization (Dissemination)

3.1 *Mission planning and rehearsal (Direction)*

Urban operation objectives can be grouped under the following categories [Hurley, 2001]:

Objective is the urban area itself: capture an urban area; defend an urban area; and isolate/neutralize an urban area.

Objective is within urban terrain: capture or destroy an enemy force; perform a focused offense (e.g. facility, individual, information, utilities, mobility); and perform a focused defense (e.g. an embassy or a group of people).

Objective is to protect and assist people in urban area: neutralize combatants; provide humanitarian assistance and domestic civil support.

These operational objectives achievement are related to critical points/centers of gravity [Peters 1997b][U.S. Army, 2000], which are elements that could have an extraordinary influence on the achievement of objectives. They can be spatial or non-spatial. The former can be associated to objects (including situations), as the latter correspond to object attributes. [Glenn 2002a][Glenn 2002b] report examples of traditional and urban critical points. Examples of traditional points are command and control, reserve forces, firepower concentrations, key intersections, high ground, and selected low-density capabilities. Examples of urban points enhance the traditional points with concentration of noncombatants, low-density support assets (e.g. hospitals and power plants), influential civil authorities, and potable water. For instance, within the Los Angeles riots case in 1992, few critical points were gun shops, fire departments, museum and galleries, welfare offices, and public utilities substation and control centers.

Knowledge about urban battlefield might help to select the urban critical points. Moreover, this knowledge can also be used for mission planning, including threat assessment and resources management along the mission. Part of mission planning and execution concerns the communication network efficiency. For instance, from the terrain geometry and the availability of resources, a map of the antennas line of sights can be drawn.

Experience from past lessons highlights the problem of friendly casualties and collateral damages. From this experience and from *a priori* knowledge about the conduct of operations, the system should be able to efficiently plan and update troops movements in order to avoid confusion, which is frequent within urban terrain. Coupled with a functional communication system, this UDFCC capability might reveal a high payoff.

The inclusion of knowledge related to weapons within the system database, might allow blast prediction analysis. Hence, the weapon (or charge) selection process might be both facilitated and optimized, increasing the possibility to reach the desired effect as well as minimizing the collateral damages.

Knowledge related to the battlefield might also serve as an input for optimal path definition. Whether for planning or for execution, optimal paths definition and selection should increase capabilities regarding navigation, target acquisition, threat assessment, and more generally, knowledge inferences [Pigeon, 2002a].

Battlefield modeling and analysis can also provide a capability for military training, improving the troops ability to react to a wide range of situations (can be past or simulated). Thus, it can assess the problem of culturally-oriented training. For an individual, the system might be capable to adapt and act as a personal assistant, from training, planning, executing, to performance evaluation. Planning can then be optimized with regard to all the system parameters, including the strengths and weaknesses of soldiers, units, equipment, etc.

3.2 *Synthetic urban battlefield up to date reproduction and formalization (Collection)*

The priority for intelligence requirements (PIRs) are based on the needs for information expressed at the level of direction (previous section). To help understand the urban battlefield, the intelligence collection plan might include the city infrastructure, the services, the culture, and the order of battles (ORBATs) of involved forces.

Based on [U.S. Army, 2000], the city infrastructure and services are defined in terms of information elements such as transportation, physical composition, and utilities (e.g. communications, natural gas, electricity, water, and health services). Intelligence concerns police, fire, medical, water, graves, trash disposal, food supply, schools, churches and other critical services. Resources and materials could be defined by the fuel resources, the material-producing factories, the machine shops, the foundries, the water supply, the source of electricity, etc. Airfield, helicopter landing zone, roadways, railways, bridges, subways, power plants, etc., should all be qualified in terms of location, size, type, features, etc.

The culture of the city can be made of norms, religious beliefs, government, population, and refugees. This includes general information about the whole population and about the social structure of the city. The social structure might be described by different elements such as ethnic, racial, religious, tribal/clans, terrorist, gang, organized crime, economic classes, political, and city government factors. The ORBATs fulfill the information about friendly, neutral and enemy force organizations. Intelligence might assess the updating of these structures in terms of units composition, status, and relationships (including actions).

Data gathering and capture related to the previous objects, might be stored within the system's memory, with respect to the five dimension data structure mentioned previously. This structure, aims to be both generic -to allow system evolution- and formal -to facilitate data processing-. The proposed structure is based on the world physical representation of space and time. The latter is considered as being either accomplished or unaccomplished with respect to the system current time.

For example, table 1, table 2 and table 3 would have been described with respect to the five-dimensions data structure. For table 1, lessons learned from Grozny and Mogadishu can be modeled by $(x,y,z,t_A,(w_G,w_M))$, where x,y,z describe the space, t_A describes a time that is accomplished, and w_G, w_M the "world" or operation dimension related to Grozny and Mogadishu. Similarly, the same dimensions, characterized by an unset w variable (x,y,z,t_A,w), can describe general lessons learned (table 2). Finally, challenges, which are unaccomplished by definition, can be modeled by (x,y,z,t_U, w), where t_U states for time that is unaccomplished, and x,y,z,w, for any operations within any space, i.e. with respect to robustness.

All of the data have to be quantified with regard to accuracy. This process is dependent on the context of the problem. For urban terrain reproduction, spatial coordinates can be required adaptively to the tactical actions that are planned. For instance, planning for snipers positioning might require a spatial accuracy of 1 meter with a *high* level of textures. Rescue simulation for helicopter pilots would require a *low* spatial accuracy with a *high* level of textures. Blast damage assessment analysis should require a *medium-high* spatial accuracy, a *low* level or an absence of textures, and a *high* level of details for target attributes related to physical composition (e.g. wood, concrete, glass). The quantities associated to *low* and *high* can be set from fuzzy membership functions. The same process applies to the parameters setting of the learning component, all-source sensors that provide system's inputs, etc.

3.3 *Urban battlefield data exploitation (Processing)*

Combination of the previous acquired data and the a priori system's knowledge allows data exploitation and enrichment through inferences. Consequently, gaps related by the lessons learned can be partially or fully assessed. For instance, based on an efficient situation monitoring, the difficulty to tell friend from foe can be significantly diminished, then reducing fratricide casualties. Another example can rely on the UDFCC capability of processing the estimation of future states in order to plan obscurant use (e.g. location and quantity). The estimation of future states is deduced from the weather conditions and the threat assessment. From the main behaviors of crowds, models can be inferred in order to predict possible reactions and future states. This can assess combatants from non-combatants sorting, as well

as collateral damage avoiding or reduction. Also, this may help to predict interactions between combatants and non-combatants with respect to the city culture and social structure.

The three dimensions of the terrain, combined with the reported threat positions (e.g. snipers, mortars, canons - which can be characterized by different accuracies) can provide a symbolic mapping of terrain with regard to the associated threat range. Mapping can also represent the electromagnetic spatial distribution (EMS). For example, a sniper threat can be assessed from the sniper position, the knowledge about the sniper range (influence by e.g. training, weapon, and weather conditions), and the terrain shape. Then, line of sights can be projected on each terrain areas, providing a terrain mapping enhanced by an attribute related to the level of threat (e.g. membership value ranging from safe zone to killing zone). Mapping of threats can be inferred for optimal path selections. Still within the DITE sequence context, a reverse process can be used for target selection. For instance, an optimal path selection would be based on troops mobility, time constraints for moving from point A to point B, and on the threats present along the path. The inverse would use the knowledge about the available BLUE weapons, their ranges, etc. Then, high payoff targets can be selected and eventually engaged.

The system's knowledge resides within its structured data, particularly the inference networks. From them, key information can be highlighted [Pigeon, 2002b]. However, when inference redundancy occurs, data fusion has to be performed. The purpose of fusion is to reduce the redundancy of links (information overload) and/or to improve accuracy by summing partial data or uncertain data. Reversing this process could lead to the identification of the place where the redundancy of links is required and/or of the context to use complementary sources for problem solving. For fusion methods, details can be found within [Pigeon, 2002a].

Management can be applied to a single resource and/or to a network of resources. From possible-worlds knowledge and learning capacities, the system should be able to predict the impact of resource on the system state i.e. system time-response to requests, bandwidth bottlenecks, tasks, etc. Constructive or destructive interferences have to be assessed in the same phase. From cost functions, optimal path e.g. possible course of actions (COAs), within space and time dimensions, could be generated (synchronously or asynchronously) for resources management.

By definitions, the UDFCC main objective and sub-objectives might drive a wide range of sensors (e.g. chemical/biological, MEMS, UAVs, UGVs, satellites, and human sources) through many possible applications. Their interaction is crucial for the viability of the system, which by definition relies on their inputs. The system capabilities to understand the urban battlefield should be applied to the direction of its sources and their protection. As a result, the system knowledge would be improved and the more it improves, the larger the chances of success are.
Finally, the system experience might be recorded within the w data dimension, and optimized by a learning capability [Pigeon, 2002a]. The learning tasks range from the system's components reliability assessment to the generation of possible worlds as estimates of futures possible COAs.

3.4 *Synthetic urban battlefield visualization (Dissemination)*

The system intellectual patrimony is generated by the combination of the reproduction of the urban battlefield, and the enriched knowledge that results from data exploitation components. Knowledge holding is not sufficient to reach information superiority. For this achievement, efficient visualization must be performed with regard to user informative need. The representation can be two-dimensional maps (2D), three-dimensional maps (3D), 3D photo-realistic urban models, etc. These can include the exterior of city structures, interiors, subterranean corridors, etc. Visualization can be performed from geometry and material attributes radiometry. For the latter, a shortcut would be to include images of texture referenced with terrain objects. Pseudo-colors might represent threats or objects of interest, still with respect to the user informative need. For instance, experience acquired at the Summit of Americas (Quebec City, April 2001), shows requirements of 2D representations at the operational level, and 3D representations at the tactical level. The next figures show examples of urban battlefield visualization possibilities.
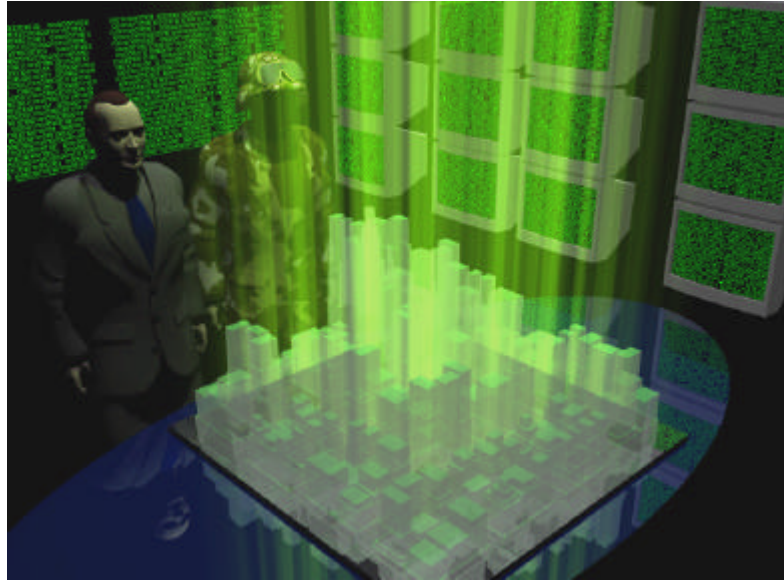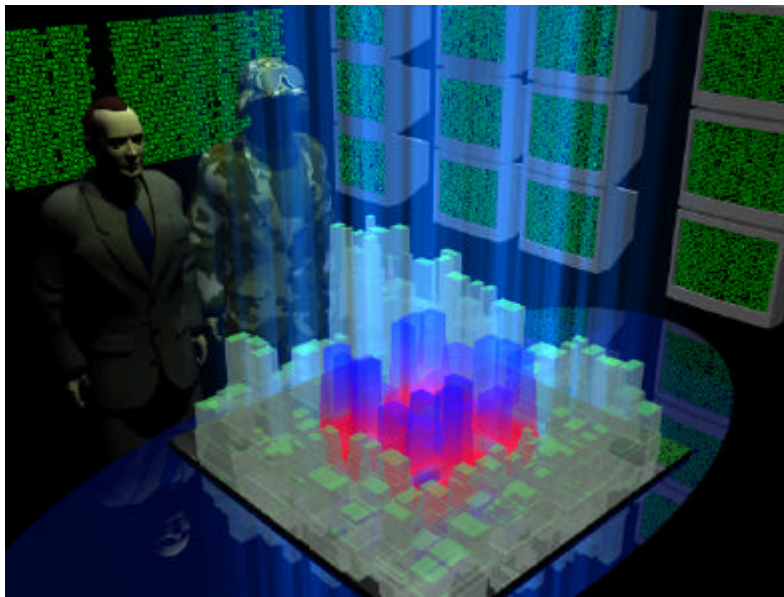

(a)

(b)

Figure 1: 3D models of Quebec City (Canada) –
**Accuracy for geometry: around 1-meter (a) and around 0,5-meter (b).**

(a)

(b)

Figure 2: Futuristic 3D holographic display for battlefield visualization - Geometrical view of the city (a) and pseudo-colors for the instance of threat assessment (b).

Figure 1 present 3D models of Quebec City (Canada). Models accuracy for geometry is around 1-meter for figure 1a, and around 0,5-meter for figure 1b. Figure 2 shows battlefield visualization within the UDFCC facility. On a table, a 3D holographic display shows to commanders (users) the system's knowledge associated to the terrain. Figure 2a exemplifies a geometrical view of the city, as figure 2b illustrates the pseudo-colors used for the instance of threat assessment. Outside the UDFCC facility, visualization might be performed similarly as figure 3 representation.
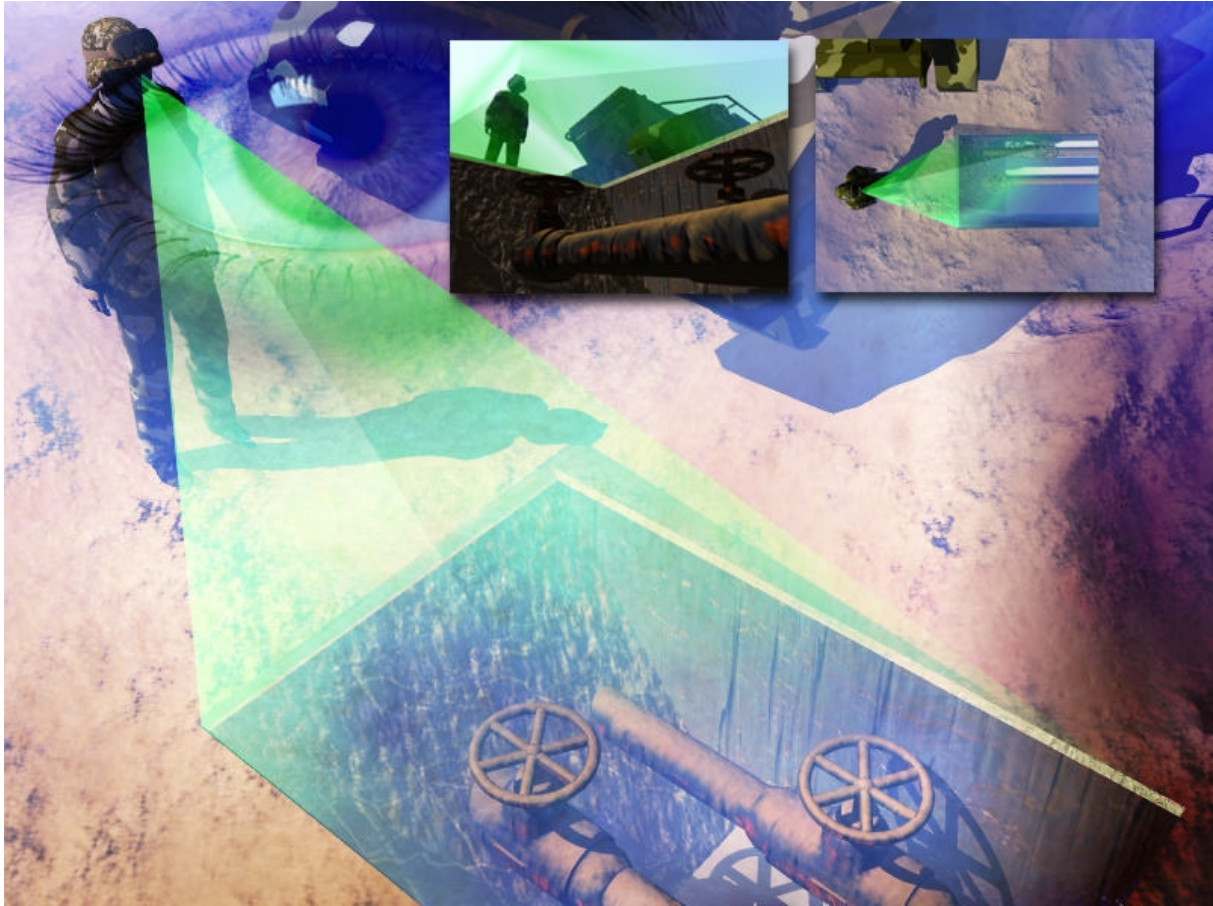
Figure 3: Futuristic representation of the UDFCC knowledge dissemination on the terrain.

Hence, based on selected information requirements with regard to communication constraints and equipment performance, the UDFCC information strengths might provide all levels of command with a clear and robust understanding of the urban battlefield. This corresponds to the fulfillment of the main objective of the system.

5. Conclusion

This paper presented a concept of UDFCC based on lessons learned from urban operations and from information system design considerations. The proposed system, which outlines were qualified as a key system for urban operations in 2020 (NATO SAS-30 study), might assess the critical need for a robust understanding of the urban battlefield.

The UDFCC facility is intended to improve the understanding of urban terrain for the planning and the execution of missions. Its visualization capabilities might be performed at both operational and tactical levels. Moreover, wargaming, rehearsal, and simulation might be realized based on possible worlds generation.

Because a key system becomes a key target, a distributed center might be designed in order to spread the expertise incorporated throughout the battlefield. As a consequence, the threat associated to the target is reduced. Efforts for UDFCC design, development, and implementation should then be placed on security and protection. A robust result could hence lead the conduct of urban operations to success, in terms of collateral damages, fratricide, psychological sequels, and other difficulties reduction or avoidance.

6. Acknowledgements

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